A.Q.

THE PERFORMANCE OF THE DESIGN-BUILD ALTERNATIVE DELIVERY APPROACH IN MILITARY CONSTRUCTION

BY

ALLAN LEE WEBSTER

B.S., Michigan State University, 1988

THESIS

Submitted in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering in the Graduate College of the University of Illinois at Urbana-Champaign, 1997

Urbana, Illinois

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THE GRADUATE COLLEGE

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CHAPTER I

INTRODUCTION

A. Background

1. The Construction Industry and Design-build

The U.S. construction industry is highly competitive, as well as fragmented. Despite this, construction has a significant impact on the U.S. economy. In 1994, the National Science and Technology Council estimated that the industry provided over 10 million jobs and produced $850 billion in project revenues (new construction and renovation) or approximately 13% of the gross domestic product (Wright, 1995). Unfortunately, the industry has been in a long downward slide and has only recently begun to recover.

The problems of the U.S. construction industry in previous decades have been well documented, discussed and analyzed. Historically, the construction industry is slow to change (Schriener, 1995). In recent decades, the fluctuation in the building market, specialization, dissatisfaction with the traditional design-bid-build process, rising costs, schedule delays, demands for higher quality and increasing litigation have forced those in the construction industry to adapt or be driven out of business. Additionally, owners who do not tolerate poor quality and high costs within their own firm cannot and will not tolerate poor business practices within the construction industry. A quote from a 1983 study by the Business Roundtable perhaps best sums up the problems of the construction industry: "Owners, who

pay the bills, no longer get their money's worth for construction in the United States" (p. 3). Alternate delivery/contracting methods, modernization, value engineering, partnering and more aggressive management practices have come to the forefront as the construction industry attempts to counter its decline. For example, the design-build delivery approach has fast become an accepted project methodology.

The U.S. Department of Commerce predicts that design-build will account for half of all nonresidential U.S. construction by 2001 (Rosenbaum, 1995). The top 100 design-build firms had $36 billion in revenues for 1995, an increase of almost $4 billion over design-build revenue in 1994 for the entire Engineering News Record (ENR) top 400 contractors (Tulacz, 1996a). Other countries utilize design-build as well. Japan uses design-build in the majority of its projects; design-build is the most popular alternative project method in the United Kingdom (Ndekugri, 1994).

2. Traditional Construction Project Delivery

The design-bid-build or the traditional approach, as it is known, has been the hallmark of construction in the public sector for decades. Under this methodology, there are separate contracts for the project design and construction. A design firm is selected on the basis of qualifications while the contractors are selected based on the lowest qualified bid (Smith, 1994). Generally, the contract awarded is a firm fixed-price or lump sum where there is no adjustment based on the actual cost of the project. Christopher Gordon, in his paper

"Choosing Appropriate Construction Contracting Method" (1994), cites the following advantages that ideally occur using the traditional method:

- Complete control over the design
- Fiduciary relationship with the designer to monitor the contractor
- Single source of construction
- Known total price before construction starts
- Price competition
- Impartial selection

(p. 197)

Unfortunately, these ideal advantages seldom occur en total. The relationship between the designer and the contractor is often adversarial, leaving the owner in the middle to mediate. Neither party benefits from the experience of the other, and since no design can be absolutely perfect, disputes may arise over design interpretations, changes and omissions. The result is often a project with cost and schedule overruns, as well as the possibility of litigation to determine who will pay.

In military construction, for example, the U.S. Corps of Engineers (USACE or Corps), like all federal government agencies, is required to seek and accept bids under the guidelines given in the Federal Acquisition Regulations System (FARS or FAR). Generally, this requires the awarding of a project contract to the lowest qualified bidder using a sealed bid process. While this requirement is intended to protect the best interests of the public, it may not always be the best method for getting a project completed on time, within cost and with the desired

quality. Within the FAR, however, there is a great deal of flexibility given to the USACE when determining the project delivery method (Webster, 1996).

3. Construction in the Public Sector

Public sector construction has significant impact on the construction industry. Public construction accounted for 27% of all construction during the first four months of 1996 (ENR, 1996). Historically, the majority of public projects have utilized the design-bid-build project delivery approach. However, with infrastructure in need of repair, modernization coupled with tighter budgets and less in-house design capabilities, public agencies have been forced to seek and utilize alternative methods of acquiring the facilities they need. In the federal sector, the Department of Defense (DOD), General Services Administration (GSA), Veterans Administration (VA), United States Postal Service (USPS), National Aeronautics and Space Administration (NASA), Environmental Protection Agency (EPA) and the Department of Energy (DOE) all have large construction programs (Pocock, 1996). Alternative contracting methods, partnering, and other innovations utilized by these and other agencies are often adopted at the state and local level. Since public construction represents a large part of the industry's business, those innovations have an impact on the private sector as well.

4. Military Construction

Military construction provides an excellent example of public sector construction. Each installation, base or post is essentially a small city with populations ranging from several hundred to over 100,000. The installation has a dynamic infrastructure that must provide utility services, a transportation network, industrial facilities, airports, offices, homes, schools, etc. As with any city, renovation, modernization and new construction are ongoing; however, with the military that effort is carefully planned, regulated and monitored. The military requires detailed monitoring of all construction projects since the Congress requires in depth reporting on all moneys spent. These requirements, both by the military and the Congress, provide an excellent source of consistent data that cannot be found in other public agencies or in the private sector.

a. The U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers, as an agency responsible for both civil and military construction, has been in the service of this country for over 200 years.
In the past, as the nation's engineer, the Corps has been responsible for military engineering, building lighthouses, exploring and surveying the western frontier, constructing buildings and monuments, developing the waters of the nation, and flood control (USACE, 1987). Today,

> The mission of the Corps is to provide quality, responsive engineering service to the nation. The Corps plans, designs, builds and operates water resources and other civil works projects, provides military construction for the Army and Air Force, and design and construction support for other Defense and Federal Agencies (USACE Missions).

The USACE employs over 39,000 people world-wide and is geographically organized into eleven divisions, forty subordinate districts and four research laboratories. The FY96 Corps of Engineers' civil works bill contains $3.2 billion for spending with over $804 million for general construction (Grimes, 1996a).

b. Department of Defense Construction

Typically, the Department of Defense utilizes in-house A/E to design civil works projects, but military projects are most often designed by contracted firms (Denning, 1992). The Air Force, Army and Navy each have design and construction capabilities to some degree. The USACE is the design and construction agent for the Army, 80-90% of Air Force Projects and DOD agencies (GAO 94-182BR, 1994). The FY96 military construction appropriations bill, enacted into law, totals $11.2 billion (Grimes, 1996b). For FY97, the DOD requested $9.1 billion for over 300 construction projects at more than 200 locations (Grimes, 1996c).

B. Problem Statement

This research investigates the performance of the design-build delivery approach for construction projects. It compares the design-build projects with the traditional projects through several performance indicators. A quantitative model is designed to measure the performance of project delivery approaches. The research also

demonstrates that the performance of the design-build delivery system has improved over time.

1. Alternative Approaches

Alternative approaches to project delivery have gained greater acceptance over the last several decades. In the past, the use of the traditional delivery approach, with the separation of the designer and the contractor, both in roles and responsibilities, has made it increasingly difficult for a project to be constructed successfully in terms of acceptable time, expense and quality. The rising risk of liability, for example, has made both the designer and the contractor extremely wary of offering consultation and advice to the other during project design and construction, respectively. This has made it extremely difficult for the owner, often not an expert in project delivery, to receive the best possible facility to meet his requirements at an acceptable price and within the time needed. A number of alternative delivery approaches are now being used in an effort to provide a better service to the owner.

a. Design-build

Design-build is a project delivery method where a single entity, either one firm or joint venture, provides both design and construction services to the owner (Twomey, 1989). Design-build offers the potential to save both time and cost since often construction can begin prior to the completion of the entire design (phased construction). Another advantage is that the designer and the contractor work together from the onset of the project. A design-build

firm may be contracted as early as the feasibility study phase of a future project. This allows the owner and the design-build firm to work hand in hand in developing the ideal facility that will meet the owner's needs and budget. While the contracting of a design-build firm may occur early on, it usually begins with the owner putting forth a "request for proposal (RFP)" with, as a minimum, a set of conceptual drawings and performance specifications. Design-build contractors may then submit a bid package with their design, construction schedule and estimated project cost that meets the RFP requirements. The owner, using a set of criteria, then evaluates each bid package. Generally, a contractor is chosen on the bases of qualification, how well the package meets the project requirements, and cost. Note that low cost does not necessarily guarantee selection under this method.

b. Bridging

Bridging involves the use of an A/E, either in-house or contracted, to complete 30-50% of a project design, or take it through the design development stage (Emmons, 1995). The A/E also assists in preparing the RFP, scope of work, evaluation factors, etc. The project then proceeds as a normal design-build project with the design-build firm completing the design and construction of the facility. Bridging is commonly seen on public projects. The Design-Build Institute of America (DBIA) is not in favor of bridging because it limits innovation and value engineering on the part of the design-build firm (Rosenbaum, 1995). In a personal interview, the Executive Director of DBIA, Jeff Beard, echoed this sentiment. Additionally, he stated that it has been difficult to get public agencies to shift from the

traditional approach even with public design-build projects. Critical to the success of any design-build project is the writing of a clear and concise RFP with true performance based specifications.

c. Construction Management

Construction management, like design-build, is a "rediscovered" alternative project delivery system. Construction management was first mandated for use in public construction projects in New York with the enactment of Wicks Law in 1921 (Levy, 1994). As a method of project delivery, it is has been growing in acceptance and use since its reemergence in the 1960's, earning over $28.5 billion in 1995 (Tulacz, 1996a). A construction management firm is retained to manage, design (or assist in the designing) and construct a project. An owner with limited in-house capability employs a construction management firm to get the best possible quality project on time and within budget with a minimum of conflict and dispute. The role the construction manager (CM) plays in a project delivery can be divided into two types:

> Guaranteed Maximum Price CM (GMPCM) is often used in the private sector. The GMPCM is usually involved with the project from its inception. A variety of services are provided throughout the life of the project. Those services include providing estimates, project schedules, constructability reviews, value engineering, bid package preparation, construction coordination, etc. As the project progresses, at some point, the CM gives the owner a GMP. The GMPCM assumes a high risk similar to that of a general contractor, since he holds the contracts with the trade contractors and has promised to deliver a project for a GMP. However, in addition to being involved with project from its inception, the GMP bid is made generally after the GMPCM has sought competitive bids from subcontractors and has added contingencies to build reserve.

> Agency CM is used most often in public works. Generally, the agency CM represents the owner from the beginning of a project for a fixed fee. The same services as a GMPCM are provided. However, the agency CM assumes no risk because the owner holds all of the contracts (Lefter, 1996).

Involving an experienced construction manager with a project from its inception offers many advantages. The principle difference between the two types of construction management and a general contractor is the amount of risk that is assumed. A general contractor (GC) assumes a very high risk on a fixed-price contract, won by low bid where no design input is given and many factors must be controlled to make a profit. The CM, either GMPCM or Agency CM, is involved with the project from the beginning, offering expertise in construction, value engineering, scheduling, quality control, budget analysis, etc. As described in the definitions above, the CM's risk may vary but it is definitely less than that of the GC.

d. Best Value Contracting

In 1991, best value contracting became available to the USACE. It is used where the technical quality cannot be defined in the specifications or statement of work (Transatlantic Division (TAD), 1995). The best value contracting process evaluates and compares other factors such as technical requirements, management techniques, and cost to give the government the best, although not necessarily the lowest, offer for a project. The relative importance of the evaluation factors must be concisely detailed to prospective contractors (TAD, 1995). The contractor has much flexibility to propose a solution that best

meets the requirements and evaluation factors. Each bid proposal is then evaluated through three steps that include non-cost factors evaluation, clarification (if required) and comparison with other offers (Army Material Command (AMC), 1994). A Best And Final Offer (BAFO) is requested from each competitor that meets the necessary requirements. This BAFO is considered along with the other stated criteria with the contract being awarded to the most qualified offer, not necessarily the lowest cost offer. The best value contracting approach requires much preparation and can be expensive and complicated.

e. Partnering

While not a true alternative project delivery system, partnering has gained a formal definition and format. Partnering is defined by the Construction Industry Institute (CII) as:

> a long term commitment between two or more organizations for the purpose of achieving specific business objectives by maximizing the effectiveness of each participant's resources. This requires changing traditional relationships to a shared culture without regard to organizational boundaries. This relationship is based upon trust, dedication to common goals, and an understanding of each other's individual expectations and values. Expected benefits include improved efficiency and cost effectiveness, increased opportunity for innovation, and the continuous improvement of quality products and services (CII, 1991).

Partnering is not a contractual agreement but rather a structured approach for the owner, the contractor and others to undertake in an effort to avoid an adversarial relationship that often leads to delays, additional costs and litigation.

The U.S. Army Corps of Engineers has been a leader in applying partnering principals to projects since 1988 (Schroer, 1994). Despite the long term relationship that the CII definition calls for, the Corps, limited by regulatory constraints, has adopted project

partnering with positive results (Rock, 1992). Typically, there is an initial partnering workshop which occurs at a neutral location with all critical players in attendance. Top management from the USACE, contractor(s), owners, etc. must also attend in order to ensure the success of the venture. An experienced facilitator helps the players to develop common goals for project success that can be achieved through a cooperative effort from all. Follow-up sessions occur both on-site and, for large projects with long duration, off-site to keep the partnering process on track.

2. Value Engineering

Value engineering is not an alternative delivery approach. However, value engineering may be used with any delivery system. Value engineering is a formalized process where high cost activities of a project are thoroughly scrutinized to find a more cost effective design or method that performs the same or better than the original (Webster, 1995). All federal departments and agencies are mandated by the Office of Management and Budget Circular A-131, Jan 26, 1988, to utilize value engineering in all projects over $100,000. Specifically, OMB A-131 states:

> Value engineering in the federal government is a means for some federal contractors and government entities to change the plans, designs and specifications for federal programs and projects. These changes are intended to lower the government's costs for goods and services and maintain necessary quality levels (DOI, 1992).

Value engineering has enjoyed great success in the public sector. An example being the Marathon Battery Superfund site where value engineering resulted in a savings of over $8

billion or 40 percent from the original design (Meng, 1994). Often, incentive clauses for value engineering are written into the contract. For example, USACE project contracts may offer a one time payment equal to 55% of the estimated savings on any adopted change. Value engineering can occur as early as the design development phase of a project and be repeated as the project develops. Under the traditional methodology, however, any accepted contractor value engineering proposal is made after the design has been completed and may require redesign on the part of the separate A/E entity.

C. Objectives of the Research

The objectives of the research are:

1. Compare/verify the performance of design-build projects with the traditional design-bid-build projects.

2. Demonstrate that the performance of the design-build delivery system has improved over time.

3. Identify any other indicators which may be of better use in evaluating construction project delivery approaches.

D. Thesis Organization

This chapter began with the description of some shortcomings of the construction industry in the United States. The highly fragmented nature of the industry has contributed to

these problems. Public sector construction was discussed, as was the role of the USACE in both civil and military construction. The need to verify the performance of military projects utilizing the design-build alternative delivery system was the focus of the problem statement. The traditional methodology in military construction and some of the alternative approaches were then presented. Chapter II is a literature review of design-build history in both the private and public sector. USACE traditional and design-build project management methodology are also examined. Measures of performance are discussed, as are the contributions of other researchers. Chapter III explains the methodology to include the use of the t-test in this research. Data from USACE and previous research are incorporated for this study. Chapter IV presents the results of the analysis. Chapter V summarizes the research and contributions, and offers recommendations for future research.

CHAPTER II

LITERATURE SURVEY

A. Introduction

This chapter reviews the history of design-build, variations of the design-build delivery approach, and the different design-build entities. An examination of design-build in both the public and private sector is given. The chapter further reviews the construction process as it applies to USACE civil works and military construction. Defining measurable performance indicators is discussed by reviewing the work of other researchers. Other studies are surveyed, particularly those having to do with military construction. Finally, a summary is given which points to the complexity of examining and defining the success of a construction methodology as well as the need for more research.

B. Design-build History

Today, design-build is considered the "non-traditional" approach. However, the concept of using one entity can be traced back to the term "Master Builders" and 1800 BC (USACE, 1994). Until the Renaissance period, one individual often directed the building of a structure with the design in his head. However, as buildings became increasingly complex, there was a separation of roles between the designer and the builder, which lead to the

establishment, by the 19th century, of what is know today as the "traditional" approach to project construction (Twomey, 1989).

1. Defining Design-build

For the purpose of this study, design-build is defined as a single point of responsibility for both the design and construction of all or a portion of a project (Twomey, 1989). In its broadest form, an owner could contract with a design-build firm to work with him from the very beginning, to consider acquisition strategies, project/facility requirements, financing, real estate services, design, and construction. While this does occur, more often an owner utilizes either in-house A/E or contracted A/E to develop project scope, performance specifications, and the RFP. Often this includes anywhere from 10% up to 50% of the developmental design. However, the design-build process is most effective when very little of the design is specified in the RFP (10% or less preferred). The DBIA suggests that the owner and consultants concentrate on "defining the problem" rather than suggesting solutions when developing the RFP (DBIA, 1994).

There are number of variations of design-build including turnkey, bridging, fast track, and build-operate-transfer.

a. Turnkey: May require the design-build firm to provide extensive services beyond design-build. Those may include:

- Financing the project

- Identifying and procuring the construction site and site data
- Obtaining regulatory permits
- Operating and maintaining the facility for a period of time to verify system functions

(Twomey, 1989)

As the name implies, the design-build contractor literally turns the keys over to the owner.

b. Bridging: Although not formally recognized by the DBIA, bridging involves the use of an A/E service (either in-house or contracted) to compile a RFP with 30-50% of a project design, along with the required performance specifications. The design-build firm then has the responsibility for final design and construction.

c. Fast track: Design and construction occurs concurrently and/or sequentially While not limited exclusively to the design-build delivery method, design-build is well suited to take advantage of fast tracking since there is a single entity responsible for both the design and the construction of the project.

d. Build-operate-transfer: As the name implies, a single design-build entity designs, builds and puts the facility into operation. At some point in time, facility operation is transferred to the owner. A variation of this would be build-operate-lease, where the owner leases the facility with or without a purchase option (Emmons, 1995).

2. Design-build Entities

Essentially there are four types of design-build entities: the design professional as the primary contractor, contractor as the primary, joint venture, and design-build organization. All have advantages and disadvantages for the owner, designer and contractor. Obviously, the design-build organization offers the most advantage for the owner in that the designer and contractor are under the same roof with no artificial barriers created from the concern of liability responsibility. Similar advantages may be found in the other types of entities if the contractor and design firm have worked together successfully on previous design-build projects.

3. Private Sector

The private sector, unlike the public sector, is not restricted to any single type of project methodology or contracting method. Owners have the single largest influence on the construction industry. They are the industry's customers. Today's successful businesses have adopted advantageous practices, such as total quality management (TQM), just in time delivery, etc. Owners do not tolerate vendors who manage their own businesses with archaic and/or sloppy methods (Schriener, 1995). The construction industry has been forced to change and adapt in order to stay competitive in both the national and international markets. Among those changes has been the implementation of alternative project delivery methods such as design-build. In a recent Engineering News Record article, it was reported that the number of design-build projects worth $5 million or more had doubled to 1,119 projects from

the same period last year, with big increases in the industrial sector (Tulacz, 1996b). Owners in almost all market sectors are taking advantage of the benefits that design-build can offer.

4. Public Sector

Design-build in the public sector has received an increasing amount of attention. However, the use of design-build is not new in the public sector. According to an American Institute of Architects (AIA) task force report (1975) on design-build, the first use of public funds in design-build procurement probably occurred in 1968 for an Indiana school building (p. 4). From these early beginnings, the use of design-build has increased in the local, state and federal sectors.

Despite the early local beginning, design-build has grown into the alternative delivery method of choice in the federal sector. A study conducted by the Federal Construction Council (1993) cites three major factors that contributed to the use of design build:

- Intensified pressure on facility departments from corporate managers and agency administrators to save time and money
- Concern about increasing construction-related litigation combined with growing uneasiness over the inherent lack of accountability under the traditional approach because of divided responsibility for design and construction
- A spreading perception that many designers do not have a good understanding of how buildings are constructed or what different building features actually cost

(p.2).

Agencies such as the GSA, Postal Service, DOD and others have been using design-build with increasing frequency since the early eighties.

The GSA is the manager of almost all non-military federal facilities. Rebuilding of the federal infrastructure has been in high gear with the GSA executing 220 major projects for nearly $1.4 billion from 1991 to 1994 (GAO, 1994a). The GSA spent 33% of its FY91 capital construction budget on design-build procurement (ASCE, 1992). Recently, the GSA, after criticism over high costs and vague performance criteria, and some regulatory policy changes, has backed away from design-build while procurement procedures are reviewed (McManamy, et al, 1994).

The United States Postal Service (USPS) has used design-build since the early seventies. In 1992, 20% of the USPS's annual construction budget of $1.2 billion was design-build (ASCE, 1992). Jerry Enverso, the USPS Purchasing Manager for Major Facilities, at a recent project delivery systems conference held by the Associated General Contractors of America, cited the following reasons why the USPS prefers design-build:

- One accountable and liable supplier
- Easier to manage
- Less adversarial relationship between the owner and the contractor
- Saves time

Actions in the federal sector have a great deal of influence on the state and local levels. Design-build is slowly gaining acceptance at these levels. A study conducted by the Building Futures Council (1995) found that only thirteen states allow design-build in public projects to some extent (p. 10). Additionally, the report notes that

> The preference for separate design and construction and cost-based selection is decades old and is based on concerns over fraud, waste and abuse that now might be outweighed by requirements of efficiency and cost and time savings (BFC, 1995).

The current design-build practices used by federal agencies are not without criticism. Walter Lewis, a member of the AIA committee on design-build, points to the lack of a national standard on the use of design-build delivery for public project requirements as a major hurdle in using this alternative delivery method effectively. The selection process of design-build firms is an issue cited in a number of studies. A number of organizations favor a Brooks Act type selection process over the use of competitive bidding for selection. The AIA/AGC recommended that the selection process be a two-step process. The first step is to compile a short list of design-build firms based on each firm's ability to perform, experience, past performance, and financial capability (AIA/AGC, 1995). The short list firms would then submit a detailed final proposal. Then, as the second step, a firm is selected based on a known set of weighted criteria that may include quality of design, construction methodology, management plan, and cost (AIA/AGC, 1995).

The expense of preparing the documents and drawings for a proposal is another concern. While compensation is not recommended for all submittals, a number of associations and reports recommend that the losing bidders on a short list receive some sort of preset stipend. Another recommendation is that the amount of documentation required be limited. This offers the advantage of not only limiting the expense for bidders, but it also reduces the time required by the selection panel. The only agency currently offering a stipend, for specific

cases, is the GSA (ASCE, 1992). Other issues that require attention are the lack of consistent RFP guidelines across the federal sector and inadequate design-build contracting documents.

5. Military Construction

The military has been using design-build for family housing since the early seventies. Starting in FY86, the Congress, in an effort to reduce procurement time and cost of facilities, required the Army, Navy and Air Force to use one-step design-build procedures for three projects (aside from housing) each fiscal year (Duncan, 1996). In 1992, unlimited use of one-step design-build was authorized under Title 10 U.S.C., Section 2862 by the Congress using performance based specifications and firm fixed-price contracting (USACE, 1994). Although the design-bid-build methodology continues to be the prevalent approach for MILCON projects, alternative methods have gained increasing attention and use.

C. Traditional USACE Project Management

The USACE project delivery process, while similar to that of the private sector, has significant differences, particularly with regard to funding and organizational setup. To fully understand how the design-build delivery system may benefit the USACE, the traditional methodology must be examined. The typical district organization chart, with respect to project management, is shown in figure 2.1. A simple explanation of the district organization may be to think of it as a construction management firm. Each division has specific

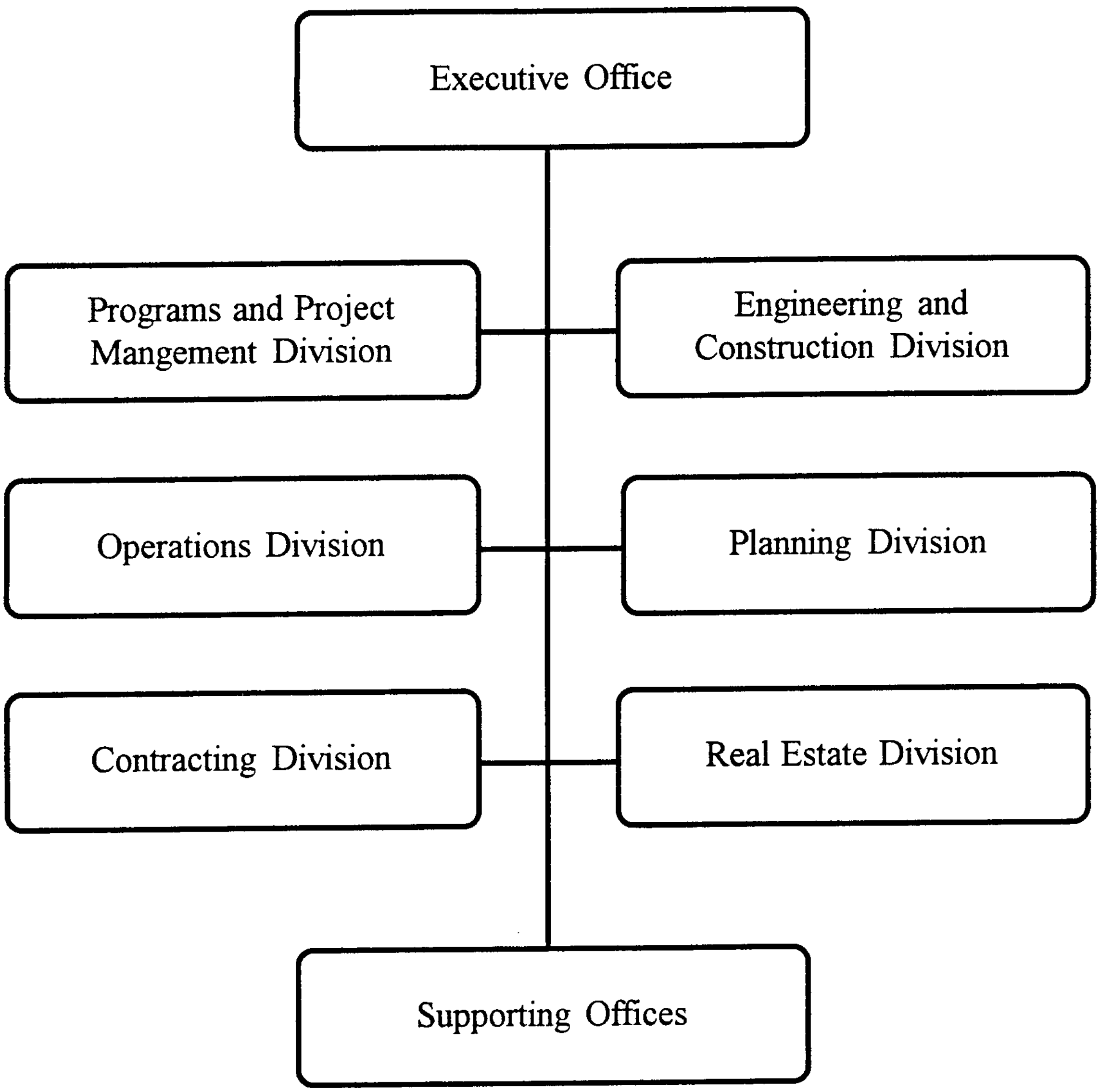

Figure 2.1 USACE District Organization Chart (Adapted from USACE Tulsa District)

responsibilities to fulfill in conjunction with other divisions in order to ensure a successful project.

1. Civil Works

The USACE Civil Works Program encompasses a broad range of facilities. USACE is the federal government's largest water resources development and management agency (EP 1105-2-10, 1990). Some areas that the USACE is involved with, responsible for, or has regulatory authority over include: waterway navigation, hydroelectric power, flood control, coastal and shoreline erosion, environmental remediation, water supply, water quality, and outdoor recreation. Planning assistance is also provided to other federal, state and local agencies involved with the same areas of concern. The undertaking of a civil works project is not a small undertaking. Federally funded projects require a great deal of planning and assessment prior to the Congress authorizing funding for the actual construction.

A traditional design-bid-build project may take up to eleven years from the start of the reconnaissance study (project definition stage) to the delivery of the completed facility to the owner (see Figure 2.2). It is important to note that there are different funding authorizations and requirements that must be attained or met throughout the entire project process. At any point of time a project may be shelved, canceled, or deferred (GAO, 1994b). Once a project has construction funding, a bid package is prepared by the appropriate district contracting division and a notice of a proposed contract is published using the Commerce Business Daily (CBD) and mailing lists. Sealed bids are received and opened in public. Although the

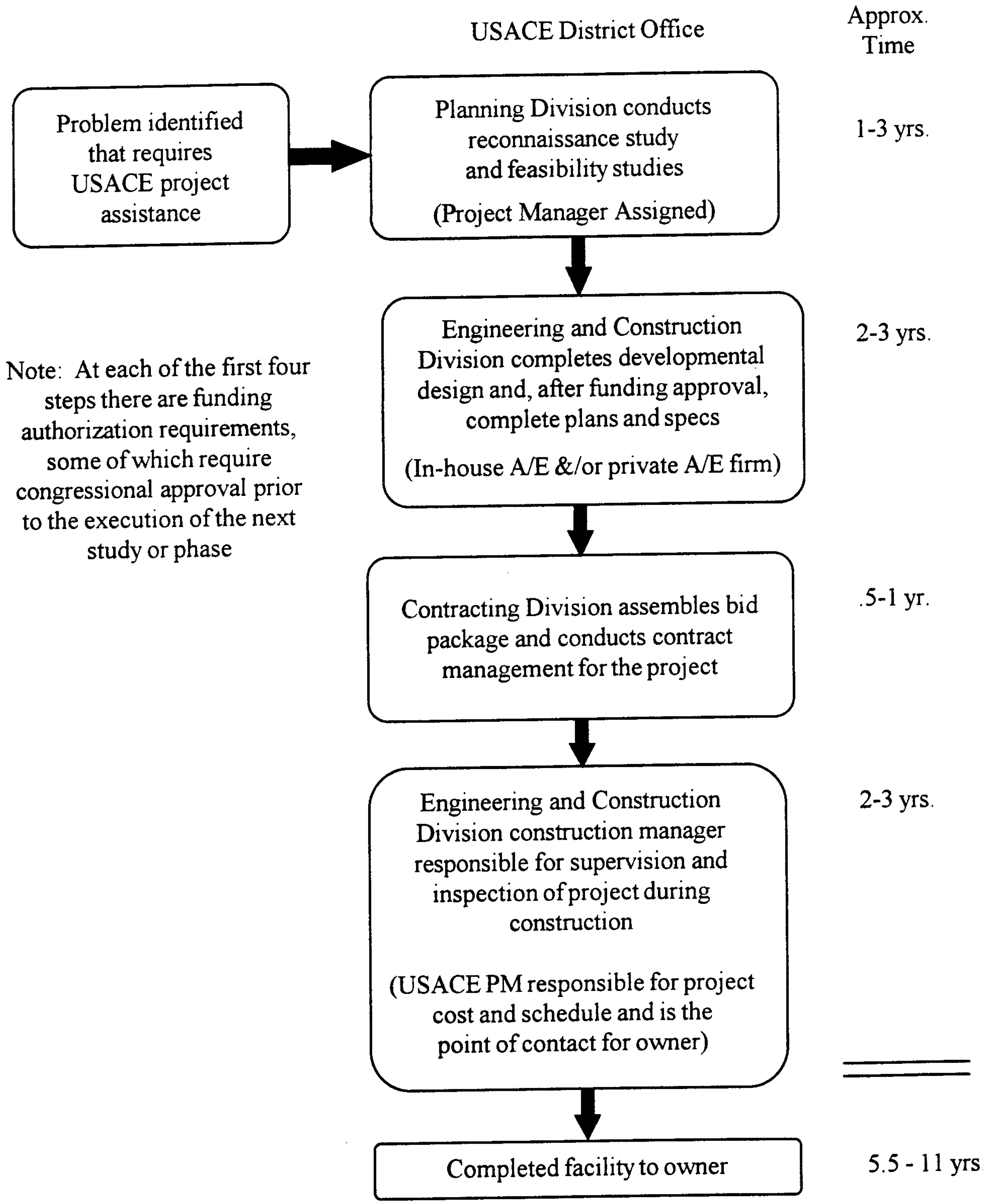

Figure 2.2 USACE Civil Works Traditional Project Flow Chart

USACE has a number of fixed-price and cost-reimbursable contracting options, the lump sum fixed-price contract is the most common contract for project construction. The bidder with the lowest qualified bid is awarded the contract for construction.

2. U.S. Army Construction

The management process used by the Army to ensure effective use of resources to accomplish its roles and missions is known as the Planning, Programming, Budgeting, and Execution System (PPBES) (AR 415-15, 1994). The Army Military Construction Program Development and Execution Regulation, AR 415-15, dated 30 Aug 1994, states that PPBES is:

> The Army's primary resource management system that is now in a biennial cycle.... It (PPBES) forms the basis for building a comprehensive plan in which budgets flow from programs, programs flow from requirements, requirements from missions, and missions from national security objectives. The patterned flow, from end purpose to resource cost, defines requirements in progressively greater detail (p. 43).

The intricacies of the overall process are not explained in this paper. It suffices to state that the Army uses PPBES, resource guidance and other management systems to plan, program, design, budget, and construct military projects. The USAF and the Navy use similar processes as well.

Proposed MILCON projects undergo a review sequence conducted by Headquarters, Department of the Army (HQDA), the Office of the Secretary of Defense (OSD), Office of Management and Budget (OMB), and the Congress (AR 415-15, 1994). USACE, the Army's

design and construction agent, is involved throughout the entire process. The process consists of four phases, each lasting one year. Possible projects must be identified up to one year prior to the first phase so that the required design effort can be met during the design year. A simplified project timeline is shown in Figure 2.3. As with civil works projects, at any time in the process, the proposed project may be canceled, deferred, or shelved. The bidding process described for civil works is used for MILCON projects as well.

Most projects utilizes the design-bid-build delivery methodology. However, the traditional approach may not always be the most cost or time effective delivery system. In addition, facilities may be required for emergency conditions, restoration of damaged or destroyed facilities, family housing, medical needs, environmental compliance requirements, Base Realignment And Closure (BRAC), and hazardous waste clean-up in a shorter time period than the process described above allows. In every case, alternative delivery systems, such as design-build, may offer significant savings in both time and money for project delivery.

D. Design-build Methodology in MILCON

There is no clear consensus among the three services as to the exact criteria leading to the use of design-build. Similarly, there is not a common design-build methodology, although all utilize similar procedures. The Navy employs four variations of design-build with the Newport Design-build method being the most prevalent. The Newport Design-build is a single-step sealed bid process with no technical evaluation. An Invitation For Bid (IFB) is put

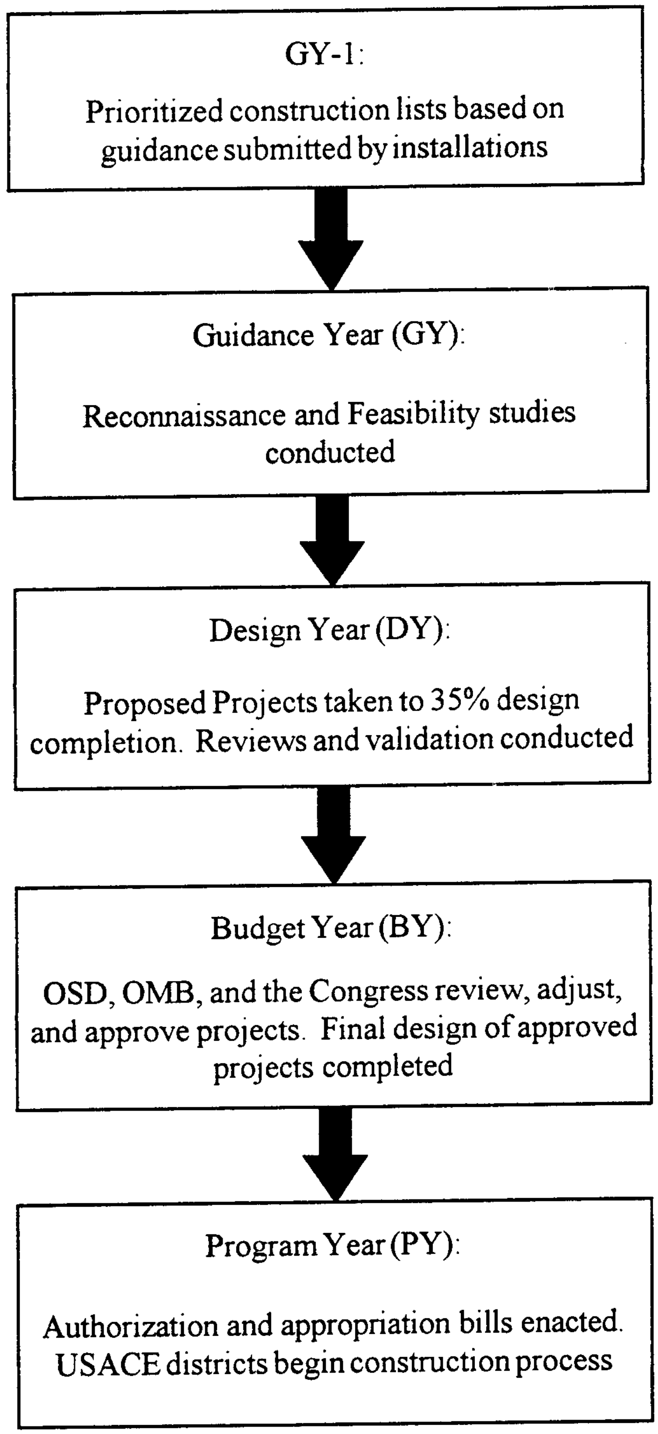

Figure 2.3 MILCON Traditional Project Flow Chart

out with 100% complete performance specifications (CSI 16 division format), 100% complete site drawings and 35% complete design drawings (Emmons 1995). As noted by the author, the Newport Design-build requires that the IFB clearly state the design requirements since there is no evaluation done (p 377).

The U.S. Army Corps of Engineers, being the primary design and construction agent for the Army, Air Force and other DOD agencies, has issued Engineer Circular 1180-1-173, dated 09 Dec 94, for using design-build in military construction. The circular explains the requirements for using the design-build process from the acquisition planning through to the administering of the awarded contract. USACE uses two types of design-build procedures, the One-step and the Two-step, with One-step Design-build being the most prevalent. Both are described below.

1. One-step Design-build

As the title implies, the One-step procedure, referred to as design-build in the engineer circular, involves the awarding of a contract after contractors have submitted responses to a request for proposal (RFP). The advantage of this process is that the contract award is based on evaluation factors and price that give the best value to the government. Lowest cost does not control the contract award but rather a series of weighted evaluation factors that include: initial construction cost, technical quality, offeror qualification, management expertise, and life-cycle cost (USACE, 1994).

2. Two-step Sealed Bidding

The Two-step sealed bidding is a hybrid approach incorporating the One-step procedure described above with competitive bidding for a fixed-price (Napier, 1990). In the Two-step procedure, technical proposals are submitted for evaluation by interested parties and evaluated. Those parties whose proposals conform to the request for Technical Proposal (RFTP) are invited to bid. The lowest bidder is awarded the contract (Napier, 1990). The Two-step sealed bidding process had been restricted to military construction, however with the presidential approval of the Federal Acquisition Reform Act (FARA) in early 1996, the Two-step selection procedure may be used for civil works as well (Grimes, 1996).

3. Design-build Process

In using the design-build process, the USACE Design-build circular states that a "corporate" approach must be adopted (USACE, 1994). This approach brings together representatives from all of the divisions within the district office as well as the owner. There are four basic teams and a source selection board (if required) that work through the six-phase design-build process:

- Acquisition planning
- Predesign activities
- Develop RFP
- Issue RFP
- Evaluate proposals and award contract

- Administer contract

(USACE, 1994).

The difficulty lies in the fact that the district is set up for the traditional approach of project delivery. The previous design-build experiences that team members have may well play a significant role in determining the success of the current project. In addition to the overriding previous use of the traditional method, design-build encourages the use of performance specifications based on national and international standards. Traditionally, projects have had to adhere to government specifications, such as the Corps of Engineer Guidelines and Specifications (CEGS) manual. Often specifications such as these differ from those used in private industry. Another issue not addressed here is the adaptation of traditional delivery contract documents to design-build. The DBIA, AIA, AGC and others have suggested formats for use.

Perhaps the most critical part of the entire process is the development of the RFP. Currently, at the federal level, there are no uniform guidelines as to the contents of a RFP. While this issue is being resolved, it leads to certain difficulties since the traditional project mind-set may be prevalent even when utilizing design-build. The AIA/AGC suggest the following eight parameters to be included in the scope of work (RFP) for public projects:

1. Program statements for the facility that describe space needs, design goals, and objectives
2. Equipment requirements
3. Other pertinent criteria (accommodations for future expansion, etc.)
4. Site information, including site survey and soil boring report

5. Any minority business enterprise, women business enterprise, or disadvantaged business enterprise requirements

6. An outline of specifications

7. Budget parameters

8. Project schedule

(AIA/AGC, 1995).

The AIA/AGC and the DBIA stress the need for flexibility in the RFP in order to allow for greater innovation on the part of potential bidders. The design-build circular states that it is imperative to develop an RFP that best defines the project requirements both technically and functionally since, after the contract award, changes to the design criteria are change orders and costly (USACE, 1994).

A contrasting view is offered by Heery, et al., pointing to the potential of conflict of interest on best design vs. profit. Among the issues cited are: owner difficulty in controlling important design details while retaining price control, and the loss of an owner retained A/E for professional advisement and bid submittal analysis (Heery, 1993). Heery favors a form of design-build bridging to take advantage of the best that design-build has to offer, while minimizing or eliminating some of the possible issues aforementioned.

E. Measures of Performance

Construction projects are successful as a result of a culmination of many factors.

However, these factors are difficult to identify and do not necessarily hold the same value from project to project. What compounds the complexity is the fact that the definition of success and hence the relative worth of a particular measure will vary depending on whose prospective is examined, the owner's, the A/E's, or the contractor's.

In the paper "Critical Success Factors for Construction Projects" (1992) by Sanvido, et al., the authors point out the problem of differing viewpoints. They also note success criteria as they relate to a building change from project to project depending on participants, scope of services, sophistication of the owner related to the design of facilities, etc. (Sanvido, et al., 1992). Despite this, they were able to determine some success criteria common to all: complete the project on time, on budget, meet a schedule, and have an absence of any legal claims (Sanvido, et al., 1992). Four success factors were found to be critical to the success of any project:

1. A well-organized , cohesive team to manage, plan, design, construct, and operate the facility

2. A series of contracts that allows and encourages the various specialists to behave as a team without conflicts of interest and differing goals (contracts must allocate risk and reward in the correct proportions)

3. Experience in the management, planning, design, construction, and operations of similar facilities

4. Timely, valuable optimization of information from the owner, user, designer, contractor and operator in the planning and design phases of the facility

(Sanvido, et al., 1992).

Fergusson and Teicholz published the results of a study, "Industrial Facility Quality Perspectives In Owner Organizations" (1994), on owner satisfaction as a measurement of

facility quality. This study was done in an attempt to give construction firms a way of determining what constitutes a satisfactory standard of performance in the delivery of a quality product. The fact that industry owners spend billions on construction and the competitiveness of the construction industry itself are additional reasons cited. The definition of facility quality must now consider customer satisfaction rather than focusing on the manufacturing-based definition of quality, i.e. product-based quality (Fergusson & Teicholz, 1994). Noting the difficulty of measuring attitudes, she selected a semantic differential scale to measure a list of 32 facility characteristics. Seventeen facilities were selected for study and the owner organization of each facility was divided into three sub groups (project management, strategic, and operations). The conclusions of the study point to the fact that throughout the owner organization there are different customers with different priorities and levels of satisfaction with the performance of the facility (Fergusson & Teicholz, 1994).

Pocock selected four objective performance indicators to use as measures of project performance: cost growth, schedule growth, number of contract modifications, and percent of modifications due to design deficiencies (Pocock, 1996). These factors were selected and others considered on the premise that these indicators are common to all projects, regardless of type. Additionally, data for these indicators were available. He also acknowledged that, while there was some subjectivity to the data, these indicators do represent four aspects of project performance as well as all parties concerned (Pocock, 1996). User satisfaction evaluations were also conducted to verify the objective indicator results.

F. Other Studies

Several professional associations have conducted limited studies on design-build in the public sector and have published reports. The same is true for several governmental agencies. Academic studies on validating the design-build alternative appear to be few. Pocock's study on validating alternative delivery methods and the Degree of Integration is the basis for this research.

The U.S. Army Construction Engineering Research Laboratory (USACERL) published a study on two early design-build projects built for the U.S. Army. The two projects selected were physical fitness centers. Conclusions included the fact that the design-build constructed facilities were completed at lower cost while maintaining the desired quality (USACERL, 1988). The projects were regarded as generally successful and became the basis for the USACERL technical report "One-Step and Two-Step Facility Acquisition for Military Construction: Project Selection and Implementation Procedures" (Napier & Freiburg, 1990).

In 1991, the USAF contracted with Engineering-Science Inc. to conduct an analysis of the USAF design-build projects that were built under the initial 1986 congressional guidelines directing three design-build procurement projects each year. These projects were regarded as essentially successful, keeping in mind that utilizing design-build delivery was new to the DOD and public sector. The analysis concluded that design-build was a successful construction contracting method and would be applicable for all project types, from those

with relatively simple requirements to those with highly sophisticated requirements (ES, 1991). While that study was encouraging, it is important to note that the study covers just five facilities with just two being of similar type.

The Federal Construction Council published a design-build study based on the experiences of seven agencies and 27 projects. Contrary to the view that design-build was advantageous for only simple projects, 24 of the 27 projects were categorized as medium or high complexity facilities. While noting that the study was not comprehensive enough for an unqualified design-build endorsement, the committee noted that most agencies have had results as good as or better than results when using the design-build approach instead of the traditional process (FCC, 1993).

As mentioned in chapter I, Pocock verified that partnering, design-build and combination alternative approaches offered significant advantages over the performance of traditional design-bid-build approach for MILCON projects. The performance of 90 traditional projects were compared with 119 projects that were completed using alternative approaches. While each alternative had strengths, no single method was clearly a "best" selection over the other approaches (Pocock, 1996). While not addressed in this study, Pocock also demonstrated that the degree of interaction was related to project performance and that alternative approaches have greater interaction amongst designers and builders.

G. Literature Survey Summary

The fact that design-build continues to be a growing means of project delivery in both the public and private sectors points to the value of the design-build as an alternative approach. Given the continuing demand for a higher quality project delivered in a shorter duration at an acceptable price, design-build delivery remains viable. MILCON projects utilizing the traditional approach cannot deliver the required facility under all circumstances. The need to take advantage of technological advances, reduce project costs and litigation, speed delivery, etc. are reasons cited to use design-build. As noted in the survey, there remain serious shortfalls with respect to the use of design-build. Clearly, design-build may not be suited for all projects.

While few formal, in-depth studies have been conducted, Pocock has demonstrated the validity of several alternative delivery approaches. An item of interest with respect to the evaluation of design-build approach was that the schedule growth of design-build was almost equal to that of the traditional approach (Pocock, 1996). Given the basis of design-build, it would not be unreasonable to expect that there would be little schedule growth. Possible explanations may include:

1. Limit of sample size
2. Lack of experience or familiarity with project type
3. Lack of experience with delivery approach
4. Type of design-build firm

5. Owner directed changes

6. Funding shortfalls

7. Report requirement shortfalls (design-build included design and construction phases while the traditional method only included the construction phase)

By examining similar data to that used by Pocock and examining several design-build projects in detail, this research will attempt to address the following:

- That the performance indicators and the comparison results of design-build vs. traditional can be repeated thus verifying the results of the previous study

- Compare the study design-build project average performance results with the alternative delivery systems results of the previous study

- Identify, any other indicators which may be of better use in evaluating design-build as an alternative delivery system

CHAPTER III

METHODOLOGY

A. Scope

This research examines the performance of projects utilizing the design-build approach in project delivery. Design-build performance objectives are no different than those of traditional projects although the relative importance of each performance objective may be different. For this study, the assumption is made that there is no difference in the relative importance regardless of delivery system. Performance is measured by objective factors such as cost, schedule, contract modifications and design deficiencies. Subjective performance indicators include: user satisfaction, project manager satisfaction, and project personnel experience with the design-build delivery method. Case studies of specific design-build projects are used to obtain subjective data. The results of the analysis are compared with the results found in Pocock's study with respect to (1) traditional projects (2) design-build projects and (3) combination projects. Combination projects include any delivery combination of design-build, partnering and/or constructability.

Data gathered for this study are from the last five years. Case study projects were selected to be after FY92. Improvements in the average results of the performance indicators can be expected for the design-build alternative delivery approach. Reasons for this expectation include the fact that collective experience with design-build projects should have increased with time since its advent in 1986 and its unrestricted availability for use since 1992. See Figure 3.1, methodology flow chart. The null hypothesis then is design-build projects from this study should perform relatively the same as those in the previous study. The alternative hypothesis is that the results from this study show an improvement in one or all of

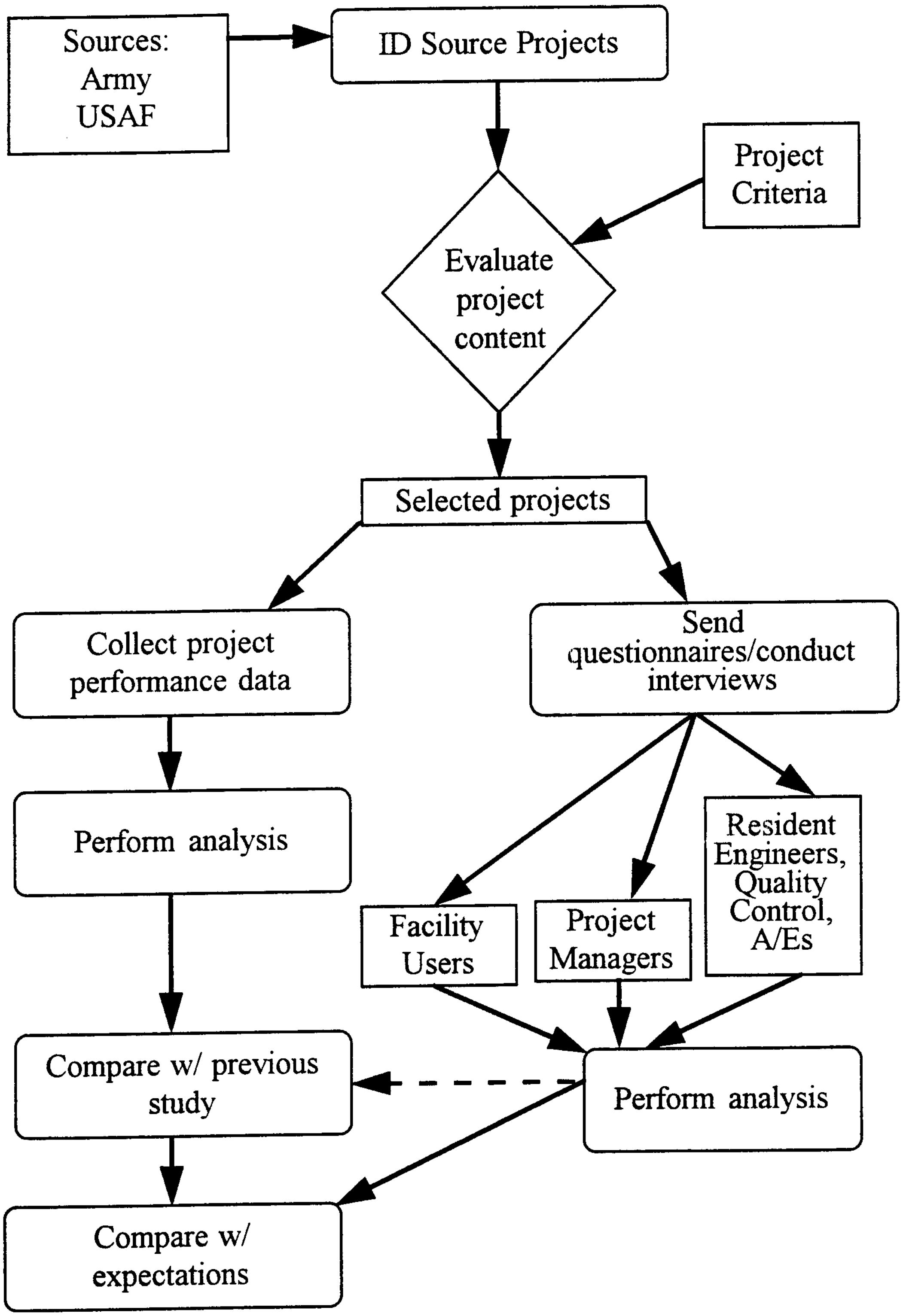

Figure 3.1 Methodology Flow Chart
(Adapted from Pocock)

the performance indicators with respect to the traditional, design-build, and combination projects from the previous study (Appendix A).

B. Data

The USACE maintains a construction database known as the Automated Management and Progress Reporting System (AMPRS). This database is used to document and monitor project progress from design through completion and serves as a historical database for all USACE projects. A large amount of data is entered, in a standardized format, for every project that USACE is involved. Selected AMPRS data is published on a quarterly basis for use by A/E and construction firms. This information is also available on the internet. Since USACE is the construction agent for the U.S. Army, USAF and other federal agencies, a wide range of project types at many different locations are available for study. MILCON projects are subject to standardized contracting, management and reporting. These projects are a good source of unbiased project data.

Initial research data were provided by the USACE Headquarters, Washington D.C. with the following initial selection criteria:

1. Continental United States project locations only to avoid distortions by overseas costs and/or artificial requirements of host nation government

2. Minimum project value of $500,000

3. All projects at least 95% complete and funded within the last five years (FY91 or later)

4. Due to differences in funding and contracting policies, no military family housing projects were included in this study.

This initial screening yielded data for over 1400 projects from all delivery methods. Only 36 of these projects were indicated to be design-build projects (Appendix B). Case study design-build projects were selected to be FY92 or after. Design-build projects financed with nonappropriated funds (NAF) were also eliminated due to the differences in contracting policies. In addition, the cost growth of one project was considered an anomaly and omitted. The case study list was further refined to select "typical projects". Projects that may be built on any number of installations were considered as "typical". Specialty facilities, such as a bioremediation facility, while an excellent candidate for design-build, were not considered "typical". Information was gathered at the local and regional levels for selected design-build projects.

While traditional project data were gathered, they were not used. As mentioned previously, the study design-build projects were compared to the Pocock study projects. The reasons for not using the more recent traditional project data include:

1. Design-bid-build remains the predominate method of use in MILCON.

2. There is little, if any, new innovation in this delivery method that has not been applied to other delivery methods during the data time period used for each study.

3. Partnering came into use by USACE in 1988, however it is used in alternative delivery methods as well.

4. Advances in the use of computers for scheduling, automation, and simulation have benefitted all delivery methods.

5. Each study used data gathered within the last five years resulting in some overlap. Pocock's project data starts with FY88 while the data for this project starts with FY91.

C. Objective Performance Indicators

This methodology includes looking at the four performance indicators identified in Pocock's thesis. These indicators were chosen for their objectivity and for the fact that data were readily available. Performance indicators include: cost growth, schedule growth, number of modifications per million dollars, and percent of modifications due to design deficiencies. Project data for cost (original and to date), schedule (original and actual), modifications, and modifications due to design deficiencies were collected for each project.

1. Cost Growth

MILCON projects, like civil works, require funding authorization from the Congress. This programmed amount is based on historical data, project analysis, construction estimates, location, etc. The initial contract award cannot exceed the programmed amount minus a statutory contingency and overhead (FAR 36.205, 1994). The actual cost of a project is contingent on a number of factors, not all of which can be controlled by the government or the contractor (i.e. weather, material shortage, labor strife, etc.). The data collected provided both the initial amount awarded and the current cost of all projects. An initial criteria for data collection was that the projects be at least 95% complete, which gives a current cost of a substantially complete project.

Even after a project is substantially complete, a final cost may not be determined for an extended period of time. Change orders, design deficiencies and claims all must be resolved

before an actual total project cost is known. A recently completed study project still has over $280,000 in outstanding issues between the USACE and the contractor. While some issues may be resolved in a relatively short time, others may take years and require arbitration or litigation. The problem of determining a true actual cost exists regardless of the type of delivery system utilized. Therefore, the percent difference between the initial contract award and the actual cost is a useful performance indicator.

2. Schedule Growth

An advantage of design-build projects is that a single entity is responsible for both the design and construction of the designated project. Schedule growth due to questions over design intent should be eliminated or minimized with the designer and the contractor under one roof.

3. Modifications per Million Dollars

Regardless of delivery method, an indirect measure of a project's performance are the number of modifications required. Modifications do not necessarily mean that there was a problem with the project. For instance, a modification may be a change due to value engineering or a wage increase for labor. Additionally, a single modification may actually be a number of changes lumped together. By dividing the number of modifications by the actual cost (in millions of dollars), the effects of a specific project's size is normalized (Pocock, 1996).

4. Percent of Modifications Due to Design Deficiencies

No set of project drawings is perfect, nor is there an expectation that perfection be attained prior to the beginning of project construction. Single point responsibility and the fact that the designer and the contractor work together under the same roof offer significant advantage with respect to the number of design deficiencies to the design-build delivery approach. Clearly, a well defined RFP will reduce the chance of misinterpretation on the part of the design-build firm and would also reduce the number of change orders due to design deficiencies.

Conversely, there may be more design issues with the traditional methodology and its linear system of project delivery. For example, the bid drawings might be completed over two years and the needs told to the A/E initially, may not meet requirements later. Inquiries from the contractor about the design often take a great deal of time to resolve since both the A/E and the contractor want minimize their own risk in making a decision involving the project design. Often, the A/E and the contractor have an adversarial relationship, forcing the owner to act as the arbitrator.

Regardless of delivery system, the current USACE system requires that the engineer on site make a judgment call as to whether a modification change order is the result of a design deficiency. This initial judgment call is further refined as the responsible parties in the Engineering and Construction division of the district office review the specifications and drawings along with the required change order. The construction manager assigns a modification reason code that is entered into the AMPRS database. While the cause of a

modification is subject to some interpretation, this is true for all projects regardless of delivery system (Pocock, 1996).

Complete information on modifications is not maintained in the AMPRS database. Additionally, as claims or issues are resolved, the reason for the modification may change. This clarification may occur long after a project is completed, and the database may not be properly updated.

D. Subjective Performance Indicators

Subjective performance indicators are perhaps just as important as objective indicators in determining a project's success. A number of factors influence subjective indicators: experience level, familiarity with delivery method and project, time requirements, difficulties on and off-site, etc. all influence personal opinion. Additionally, these factors weigh differently for each project.

1. User Satisfaction

User satisfaction is an important subjective measure since ultimately it is the user that must utilize what was designed and built. The difficulty lies in the fact that there are often multiple users with differing needs and backgrounds. Fergusson, as discussed in chapter II, conducted an industrial facility quality study that was based on distinct owner subpopulations. A maintenance worker, clerical worker and executive all have differing perspectives on the usefulness of a building.

Since this study examines the design-build process, the definition of the user is further expanded to include the project managers, construction managers and resident engineers.

Information was sought on selected projects; two questionnaires were used for the study. The first, for the facility user, was the same as that from Pocock's study, which was based on those used by Fergusson and the Department of Defense (Pocock, 1996). The users were asked about their satisfaction with the facility with respect to project delivery method, design and use (see Appendix C). The second questionnaire asked more detailed questions relating to familiarity with the design-build process, previous experience, etc. and was addressed to the project managers, construction managers and others who were involved in the process (see Appendix C).

2. Project Management Satisfaction

Project management satisfaction with a facility and delivery approach is used as a surrogate for measuring quality. The Fergusson study points out that while "quality" is a popular term in the construction industry, there is no definitive definition (Fergusson, 1994). Conformance with the design and specifications is a basic and narrow definition of quality. Meeting this definition of quality is, perhaps, a minimal requirement of the traditional delivery process. Design-build projects must conform with (unless otherwise specified) the industry standards that meet the performance specifications of the RFP. The industry standard is subject to interpretation; the owner and the design-build firm commonly differ in this interpretation, particularly when cost is involved. The RFP is a crucial element to the success of the project. The problem lies in writing an RFP that clearly defines the user's requirements and desires while not limiting the design-build firm's ability to be innovative in design and material use. No direct attempt is made to subjectively measure the "quality" of a design-build facility. While the satisfaction of the USACE management personnel with the facility and the delivery process will change from one project to the next, their satisfaction is a useful

subjective measure. The questionnaire (see Appendix C) was sent, or conducted via telephone, to project mangers, resident engineers, Q/C engineers, etc.

3. Experience

The previous experience of the owner, the owner's agent (USACE) and the design-build firm in conjunction with each other, the design-build process and the desired facility type play an important role in determining the success of a project. Note that the previous experience among the involved parties does not necessarily have to be with design-build nor with the exact same type facility. Rather, it is more important that there has merely been previous experiences. These experiences, both positive and negative, serve as a constructive foundation to form the basis of a working relationship. The learning curve of working together on a new project would ascend much quicker than a new relationship between USACE personnel and a previously unfamiliar firm. The questionnaire (see Appendix C) sent, or conducted via telephone, pertained to project development, construction, claims, etc. with respect to design-build. This information is used to supplement the objective data.

E. Analysis Methodology

As in the Pocock study, the category average and variance were found for the study design-build project data. In addition, using the two-sample student t-test, the performance of design-build projects is compared to the performance of traditional, design-build and combination project results from the previous study. The t-test is used to determine if the means of two samples are equal or if the null hypothesis can be rejected. The test produces a p-value that can be considered significant if the value is less than 5% and highly significant if

the value is less than 1% (Taylor, 1982). The p-value is the probability that rejecting the null hypothesis would be an error.

The p-value boundary values of 1% and 5% are, perhaps, more appropriate for the physical sciences. Studies involving the construction industry are not an exact science, therefore a more appropriate boundary limit of 10% has been selected. The performance indicators of the design-build approach are expected to either show improvement or no change when compared to the traditional approach, so the one-tailed p-value is used. Similarly, the one-tailed test is also used when comparing the study design-build with the results of previous study design-build and combination categories.

Objective indicators are used to form the basis of conclusions, then subjective indicators are used to compliment or contrast those findings. Additional indicators and their data were sought for selected case study projects.

CHAPTER IV

RESULTS AND ANALYSIS

A. Introduction

This chapter presents a comparison of the performance indicators of the study design-build projects with the project performance results of the Pocock study. As noted in the literature survey and in other research such as that by Sanvido, there are a number of criteria that indicate success for all members involved in a project. The four objective performance indicators used by Pocock and this study represent such criteria. In addition, the t-test is used to verify that there are significant differences in the performance of design-build projects and traditional projects. Subjective analysis of selected projects is utilized to compliment or contrast the findings. Additionally, the possibility of other indicators is examined.

B. Design-build Projects

This study examined 29 design-build projects used in this study. There were no family housing projects or nonappropriated fund (NAF) projects included. Projects were all USACE projects but involved both USAF and Army military construction. The traditional approach to project delivery continues to be the delivery system of choice for most military construction. Additionally, 90 traditional projects, 40 design-build projects and 16 combination projects

from Pocock's work were used. The Pocock study involved projects from the Army, Navy and Air Force (Pocock, 1996).

C. Average Project Performance by Category

Table 4.1 is a summary of the results of the study design-build projects and those projects used from Pocock's work used for comparison. This is a summary of 175 projects. A complete listing of the project performance indicators for each project can be found in Appendices A and B. Similar to Pocock's work, each performance indicator was analyzed using the two-sample t-test with unequal variance. The category average, the variance, and the p-value for each performance indicator by category is listed in Table 4.1.

The p-value is the probability that rejecting the null hypothesis would be an error (see methodology). The null hypothesis is that study design-build projects perform relatively the same as those in the previous study. The alternative hypothesis is that the study design-build projects show improvement in one or all of the performance indicators.

1. Comparison with Traditional Projects

The study design-build projects had significantly less average schedule growth, modifications per million dollars and modifications due to design deficiencies when compared to the traditional delivery system performance. While the study design-build average cost growth was 6.50% versus the 8.48% average cost growth in traditional projects, the p-value

Table 4.1 Average Project Performance

Performance Indicators	***Study Design-build***	**Pocock study**		
		Traditional	**Design-build**	**Combination**
Cost Growth (%)	6.5	8.48	6.37	10.44
Variance	113	141	59	100
p(T,=t),one tail	0.20294	-	0.1135	0.2460
Schedule Growth (%)	15.04	27.76	26.23	18.76
Variance	906	1099	1285	541
p(T,=t),one tail	0.03982	-	0.4107	0.0978
Modifications per Million Dollars	5.43	8.3	6.8	4.95
Variance	10	37	36	7
p(T,=t),one tail	0.0007	-	0.1081	0.0004
Modifications due to Design Deficiencies (%)	24.4	41.84	9.39	15.18
Variance	459	344	157	329
p(T,=t),one tail	2.16E-04	-	6.93E-15	1.34E-05

did not meet the 10% boundary limit to reject the null hypothesis. In other words, the difference was not significant.

The average number of modifications due to design deficiencies for the study design-build projects proved significantly lower than that of the traditional delivery system (24.40% vs. 41.84%). This was not unexpected given the advantages cited previously of the design-build process. However, this was the only performance indicator where the variance was higher (459 vs. 344).

The 15.04% average schedule growth was less for the design-build projects than the 27.76% schedule growth found in the traditional projects. The p-value of almost 4% indicates that this difference is significant. These results do show a better performance than the results of the original study where the design-build projects had an average schedule growth of 26.23% with a p-value of 41%. Possible explanations for the improved performance may include the fact that the owners, the USACE and design-build firms are more familiar with the design-build process and its use in military construction. The smaller sample size of this study (29 versus 40) may also impact this result. Figure 4.1 shows the summarized results graphically.

2. Comparison with Previous Design-build Projects

The study design-build projects were compared not only with the traditional projects of the Pocock study but also with the design-build projects and combination projects,

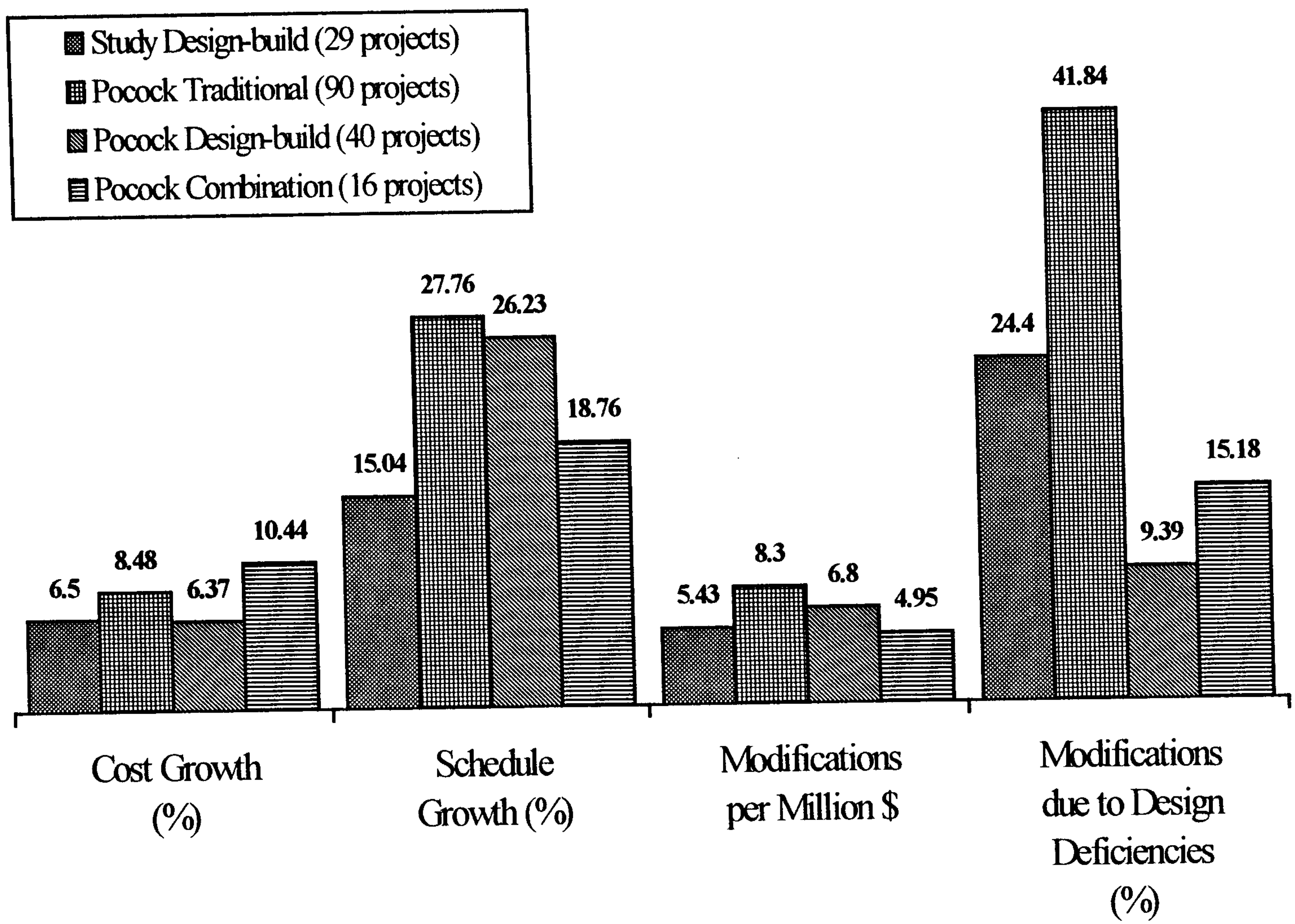

Figure 4.1 Average Project Performance Comparison

respectively. As discussed in the methodology, improvements in all categories should occur given unrestricted use of the design-build delivery method since 1992 (formerly limited to three MILCON projects per year for each service). Increased use leads to a greater understanding of the delivery system, and it is surmised that this leads to better performance. When compared to traditional projects, the study design-build projects did perform significantly better in the average number of modifications per million dollars than the previous study's design-build projects. The average schedule growth was also better in the study design-build projects, although there was not a large difference in the p-values when both were compared with the traditional projects (see Table 4.1).

The study design-build performed unexpectedly worse with the performance indicator of modifications due to design deficiencies when compared to the performance of the previous study's design-build projects. While not substantiated, there may be a greater tendency to call a modification a design deficiency on the part of USACE since USACE personnel are now more familiar with the design-build delivery system, the use of commercial or national standards, RFP writing requirements, etc. The variance between the two also differed greatly (459 vs. 157).

Using the two sample t-test with unequal variance to compare the study design-build projects and the Pocock design-build projects shows that only the schedule growth performance indicator was better, but with a p-value of 9.5% (see Table 4.2). The p-value of the modifications due to design deficiencies performance indicator is misleading since the one-tailed t-test was used with the expectation that performance would be better.

Table 4.2 Study Design-build Projects vs. Pocock Design-build Projects

Performance Indicators	***Study Design-build***	**Pocock Design-build**
Cost Growth (%)	6.5	6.37
Variance	113	59
p(T,=t),one tail	0.47763	
Schedule Growth (%)	15.04	26.23
Variance	906	1285
p(T,=t),one tail	0.09587	
Modifications per Million Dollars	5.43	6.8
Variance	10	36
p(T,=t),one tail	0.12376	
Modifications due to Design Deficiencies (%)	24.4	9.39
Variance	459	157
p(T,=t),one tail	1.15E-03	

3. Comparison with Combination Projects

Recall that combination projects are projects that include any combination or all of the following: design-build, partnering and constructability. Partnering was adopted by the USACE for use with all substantial projects in 1988. While not an instantaneous implementation, experience has grown. Partnering is often used regardless of the delivery system selected. The study design-build projects indicators were better in average cost growth and average schedule growth than combination projects. However, like the Pocock design-build projects, the study design-build projects did not perform as well as the combination category in the average number of modifications per million dollars (5.43% vs. 4.95%). The study design-build average schedule growth of 15.04% was better than the 18.76% of the combination projects (see Table 4.1). The average number of modifications due to design deficiencies was higher when compared to the combination projects (24.4% vs. 15.18%).

Using the two sample t-test with unequal variance to compare the study design-build projects and the Pocock study combination projects shows that the study design-build did not perform significantly better in any of the four performance indicators (see Table 4.3). Again, the p-value of the modifications due to design deficiencies performance indicator is misleading since the one-tailed t-test was used with the expectation that the performance of the study design-build projects would be better than the combination projects.

Table 4.3 Study Design-build Projects vs. Combination Projects

Performance Indicators	***Study Design-build***	**Pocock Combination**
Cost Growth (%)	6.5	10.44
Variance	113	100
p(T,=t),one tail	0.11425	
Schedule Growth (%)	15.04	18.76
Variance	906	541
p(T,=t),one tail	0.33133	
Modifications per Million Dollars	5.43	4.95
Variance	10	7
p(T,=t),one tail	0.29996	
Modifications due to Design Deficiencies (%)	24.4	15.18
Variance	459	329
p(T,=t),one tail	0.06754	

D. Other Performance Indicators

The four performance indicators above, either direct or indirect, are excellent measures of the success of project delivery systems. Claims information was sought for selected projects but not used. The problem discussed previously with modifications holds true when seeking claims information. Regardless of the delivery method, most projects have claims made by the parties involved. Many are quickly resolved during the course of the project or shortly thereafter. Others must be solved through the use of alternate dispute resolution (ADR), board of contract appeals (public contracts), or as a last resort, litigation. The resolution of a claim may take years. In addition, it is difficult to determine if any of those claims were directly related to a particular delivery system.

E. Subjective Performance

Several projects were selected for closer examination, and more detailed information was sought. Interviews were conducted with project managers, construction managers, resident engineers and others who were involved with the selected design-build project. Questions were asked concerning previous experience with the design-build process, satisfaction with design and construction of the project, etc. (see Appendix C). There was some difficulty getting information on the selected projects; however, two projects provided detailed information on the project and the design-build delivery process.

1. A-10 Aircraft Maintenance Facilities

a. Background

The A-10 aircraft maintenance facilities consist of three buildings and are located on an USAF base. The facilities were required as a part of the Base Realignment And Closure (BRAC) program and were subsequently needed in a shorter time period than the traditional project procurement process allowed. The owners (USAF) were involved from the inception of the project with a definite design footprint in mind due to complex aircraft maintenance requirements and a strong local exterior architecture policy. An owner representative was interviewed about this project and was generally satisfied with the facilities.

b. USACE District and Personnel

The USACE district had been involved with design-build projects in the past; however, this probably was the first design-build aircraft maintenance facility to be constructed by the district. Both the project manager and the construction manager had some past experience with the design-build delivery approach. Additionally, the construction manager had been involved with this type of facility using the traditional approach. The design-build entity, experienced both with aircraft facilities and military construction, had not worked with this district prior to this project. Following are comments from the interviews:

- Project was not originally intended to be design-build.
- Construction started prior to design completion (phased construction).

- Large amount of owner specified design requirements probably hindered taking full advantage of design-build benefits.
- Performance oriented specifications allowed contractor to have more latitude in meeting design requirements.
- Weekly meetings for all parties concerned allowed for clarification, coordination, and anticipation of possible problems.
- It was sometimes difficult to reach consensus on issues in a timely manner.
- Design-build approach required more managerial and administrative effort.
- There was a definite learning curve with respect to writing the RFP.

2. Global Training Facility

a. Background

The construction of this facility involved the conversion of an existing one story building and new construction to meet floor space requirements. The new facility was needed in a short time period.

b. USACE District and Personnel

The USACE district had been involved with design-build projects prior to this project. Additionally, the district, project manager and construction manager had worked with the selected design-build entity on previous projects although all of those projects were design-bid-build. USACE personnel, owner representatives and other concerned parties developed

the initial design requirements in just three days, utilizing a formal process known as a charette. The charette is a relatively new concept used to compress the time required to get a project to the 10% design stage in one week (USACE, 1996). Following are comments from the interviews:

- Execution of design and construction was quicker.
- Project benefited from previous experiences of USACE personnel with design-build entity.
- There was a learning curve on the use of industrial standards vs. Corps standards.
- It was time consuming for the managerial staff.
- A timely decision was sometimes difficult to reach due to number of players involved.
- Personal satisfaction was higher due to involvement with both design and construction.

3. General Satisfaction and Commentary

Questions with regard to the satisfaction with the design-build process, planning and design of the facility, and the completed facility were given a rating scale of 1 to 10. Table 4.4 shows the average satisfaction rating and variance with respect to the design-build process for the selected projects.

Table 4.4 Average User Satisfaction

Project	Average Satisfaction	Variance
A-10 facilities	6.7	2.01
Training facility	8.5	2.86

It is important to note that there were not enough responses to consider these numbers as representative of all the design-build projects. The number is still meaningful since the personnel interviewed continue to be involved in projects using the design-build delivery system.

The results of the survey indicate that previous experience with the design-build process and the design-build entity do have a positive impact on the project. Early involvement of all key players, such as the owner, ensures that needs are clearly defined, although clearly translating needs in performance specifications can be difficult. Personnel generally favored using the design-build process when it was appropriate. In an interview by the author, the comment was made that design-build was not appropriate for a particular project and that neither time nor money was saved (Anonymous, 1994). It should be noted that the reasons for selecting design-build and their impact on project success are not addressed in this study. A synopsis of the comments on design-build utilization is given below.

- Design-build is time consuming for managerial staff.
- Owner involvement throughout the entire process facilitates project success.

- Approximately 35-45% of the design was sent out with RFP.
- Learning curve exists for the use of industry standards.
- RFP must clearly define owner requirements in performance terms.

The 35-45% design sent out with the RFP is high by DBIA standards. This may indicate that a form of bridging is favored by USACE districts for most design-build projects. However, recalling the current appropriation process, there is a 35% design requirement in order to provide an accurate project budget estimate to the Congress. A need for a clear and concise RFP was also cited as a requirement for successful use of the design-build process. Vague requirements or lack of industry standards knowledge, when writing the RFP, leads to designing and constructing something less than desired by the owner. Change orders, delays and claims also result from a poorly written RFP.

CHAPTER V

CONCLUSIONS, CONTRIBUTIONS AND FUTURE RESEARCH

The design-build delivery approach, like other alternative delivery systems, continues to gain use and acceptance in military construction. This research set out to verify that there are significant improvements in the performance of design-build projects over the traditional delivery method. The performance of the design-build process was compared not only with traditional projects but with combination projects and the design-build projects of a previous study.

Regardless of delivery method, the four performance indicators used are common to all projects. Cost growth, schedule growth, number of contract modifications per million dollars, and percent of modifications due to design deficiencies are objective indicators with data readily available. The average performance and variance for the study projects were found and compared to previous study data with significance demonstrated through the use of the two-sample student t-test. There were 29 USACE design-build military projects in this study used to verify and validate the analysis from the Pocock study involving 90 traditional projects, 40 design-build projects and 16 combination projects.

A. Conclusions

1. Study Design-build Projects Performance Verifies that this Alternative Delivery System Performs Significantly Better than the Traditional Methodology.

Design-build projects perform significantly better than traditional projects. This better performance was determined to be highly significant through the use of the t-test in schedule growth, modifications per million dollars and modifications due to design deficiencies. Variance was lower in all but modifications due to design deficiencies. When compared to traditional projects, the study design-build projects performed better than the Pocock design-build projects in both average schedule growth and average number of modifications per million dollars. The study design-build projects average performance for design deficiency modifications, while better than traditional project performance, had a higher average versus that of the Pocock design-build projects.

2. Performance was Better Over that of the Pocock Design-build Projects in Two of the Four Performance Indicators.

The study design-build projects did have a better schedule growth average and modifications per million dollars. The study design-build projects average schedule growth was over 10% less than the Pocock design-build project average. When compared using the t-test, the study design-build project schedule growth performance indicator was the only indicator determined to be significant.

The study data was collected for both U.S. Army and USAF projects managed by USACE. Pocock's data included projects managed directly by the USAF and some projects from the U.S. Navy as well. While the methodologies of the USAF and Navy do not exactly match that of the USACE, the requirements and processes used are similar.

3. Study Design-build Projects Performed Better than the Previous Design-build Projects when Compared to Combination Projects.

The Pocock design-build projects had a better average cost growth than the combination projects. The study design-build projects performed better not only in cost growth but in schedule growth as well. Additionally, the modifications per million dollars was only 0.5% higher than that of combination projects (5.43% vs. 4.95%). Despite this, when using the t-test, none of these were determined to be highly significant.

Partnering was adopted in 1988 by the USACE and has been widely implemented for all projects regardless of delivery system. Given this fact, and the unrestricted use of design-build in MILCON since 1992, it is expected that the current study's projects at least match the results of the combination projects studied previously.

B. Contributions

1. Design-build is a Successful Alternative Delivery System

The design-build delivery system has significant advantages over the traditional approach for military construction projects. While it cannot be conclusively said that the design-build approach is the best approach for all projects, it has been demonstrated that design-build projects perform better over design-bid-build projects.

2. Demonstrated Improvement in the Performance of the Design-build Delivery System Over Time

This research showed that the performance of design-build projects has improved since the 1992. The study design-build projects, when compared to previous work, showed improvement or closely matched the average results in three of the four performance indicators. Modifications due to design deficiencies was the only performance indicator to have an increase. While it is expected that with increased use of the delivery process, design deficiencies decrease, possibly, USACE personnel, now familiar with the design-build methodology as well as commercial standards, are more willing to state that a shortcoming is the result of a design deficiency. The lack of formal RFP guidelines leads to failure to define owner's needs in terms of performance requirements. This, subsequently, raises the probability that design deficiency claims will increase.

By comparing the study projects with the Pocock design-build projects, improvement was shown in two of the four performance indicators (average schedule growth and average number of modifications per million dollars). While improvement was not demonstrated over all performance indicators, as USACE personnel increase their knowledge and experience in the use of the design-build delivery system, overall project performance should improve. Additionally, these same performance indicators also identify areas where changes need to be made.

3. Validation of the Use of Four Objective Performance Indicators to Measure Project Performance

This research validates the use of the following objective performance indicators in project delivery system evaluation: cost growth, schedule growth, modifications per million dollars, and percent modifications due to design deficiencies. Pocock, in his doctoral research, identified that these four indicators can be used to evaluate any completed project with detailed records. Subjective measures should be used to supplement the objective performance indicator results.

4. Additional Performance Indicators

Other performance indicators, such as the number of claims, were sought for the selected case study projects. For federal projects, once a projected is accepted, there can be no additional claims from anyone involved in the project except for fraud, latent defects, gross

mistakes, and warranty failure (Lefter, 1996). This may result in a number of claims being filed on unresolved issues prior to final acceptance. The actual number of project claims may not be known for some time after project completion. Information on the number and type of claims for completed projects proved to be difficult to attain. The A-10 aircraft facilities project, for example, although completed over a year ago, still had 11 claims or issues pending.

C. Future Research

The type of data available is a limiting factor for analysis of completed projects. While the USACE AMPRS data are fairly comprehensive, regardless of delivery system, a portion of the data entered into the database may not accurately represent a project. As indicated previously, long after the project is substantially completed, reasons for modifications change, costs are adjusted, etc. The changes may or may not reach the database. This makes the research somewhat reactive since it is dependent on the data collected by others. Additionally, the AMPRS database was originally written for reporting on traditional projects and does not necessarily require the reporting of items particular to an alternative delivery method.

1. Validate Design-build Delivery System Performance Results with Ongoing Projects

This work would compare the performance of the design-build approach with the traditional methodology through the use of ongoing projects. Rather than depending on data from completed projects, a number of future projects should be analyzed from the time the delivery system is selected through and beyond substantial completion.

a. Background

At least ten project groups should be selected for study, half being traditional and half being design-build. Each group of projects should be similar in type, duration and dollar amount awarded. Military construction projects are best suited for this study. MILCON projects offer the advantages of standardized procedures in project planning, programming, design, budget, construction management and reporting provide not only continuity but a large amount of accessible data. Project management should not be conducted by a research group but by USACE district personnel. Extra reporting requirements should be minimized to allow the study projects to be completed as normally as possible.

b. Project Selection Criteria

1. MILCON project with minimum value of $500,000
2. Similar projects constructed previously
3. USACE staff experienced in design-build alternative approach
4. Construction firm or design-build entity has had previous experience working with MILCON projects and USACE

5. Project duration of 12 to 18 months to allow for closure of claims, reasons for modifications, and final project cost

c. Performance Indicators

1. Objective Performance Indicators

Cost growth, schedule growth, number of contract modifications per million dollars, and percent of modifications due to design deficiencies are four performance indicators that should be used for the study. In addition, other performance indicators would be considered. Data would be collected for project claims, requests for information, value engineering, quality assurance/quality control problems, construction methods, safety, local labor availability and skill level, time required to administer and manage project, etc. The ability to interface with the USACE personnel directly administering the project, as well as receiving report data directly from the district as the project progress, provides a unique opportunity for study.

2. Subjective Performance Indicators

Subjective performance indicators should be greatly expanded since evaluations and interviews of the personnel involved with the projects could be conducted through out the entire process. User satisfaction, management perceptions, experience level and other subjective indicators should be identified and assessed from contract award to project completion and beyond. Key players from the owners, contractors and managing USACE personnel should be identified. These players could provide significant insight on the delivery

methodology as it relates to the project in question through the use of periodic interviews and questionnaires.

d. Methodology

This multi-year study should require that projects be identified and selected for study prior to the initiation of construction. Ideally, projects would be selected shortly after the delivery method selection so that all project parameters and research requirements could be clearly identified and in place. Data would be gathered through the use of the standard project reporting requirements, interviews and evaluations. Analysis would involve a comparison of the two delivery approaches using identified objective performance indicators. Category averages, variance and the use of the two-sample student t-test would serve as the basis for the comparison. Subjective performance indicators would supplement the objective indicators but may assume a greater weight given the availability of and access to project personnel. Finally, the degree of interaction between key project players and its relationship to project performance, as studied by Pocock, could also be incorporated into this study.

2. Incorporate Selection Analysis into Research

The reasons for selecting design-build over traditional methods vary. This research did not attempt to determine why design-build was chosen or if it was appropriate for the projects in question. The issue is further complicated by the fact that there are significant differences in the selection methodology of the public and private sector. Budget, time

limitations, regulations, and other project requirements may play a significant role in delivery method selection. Any one of these requirements may override the selection of the delivery method best suited for the project. As a result, project data and results could be unduly influenced by the selection process. Research is needed that identifies influential factors and the impact on the project outcome that these factors may have.

3. Expansion of Performance Indicators

The performance indicators, both objective and subjective, used for this study are not the only indicators of project performance. Given the complexity of determining project success, a better method of identifying, measuring and incorporating indicators is required. Subjective indicators such as the experience of key players with the project type and delivery process need to be examined. The effect on project success, if any, by the type and experience of design-build entity selected should also be examined. The value of objective and subjective indicators should be weighted so that a more comprehensive evaluation of a delivery system will be achieved.

APPENDIX A

PROJECT LIST

CATEGORIES AND PROJECTS	COST GROWTH (%)	SCHEDULE GROWTH (%)	MODIFICATIONS PER $ MILLION	MODIFICATIONS FROM DESIGN DEFICIENCIES (%)
POCOCK TRADITIONAL				
(Army) 1600M USARC-MRC/OMA	7.68	23.61	6.28	
Equip. Maint. Facility	9.53	3.56	4.35	0.00
Harvil Renovation, Phase II	5.54	10.19	5.36	26.67
Tactical Equipment Facility	13.72	27.95	3.56	25.00
POL Storage Facility	2.56	47.11	1.21	
Child Support Center	2.54	0.00	2.51	
Parachute Packing Facility	7.04	33.33	4.64	
Freefall Simulator	9.29	16.85	5.12	
Academic Facility	3.89	54.09	3.49	
Group Ops Complex	5.22	129.44	6.32	
Company Ops II	2.40	46.67	3.71	
Sewage Treatment Facility	3.40	165.11	2.20	
Vehicle Maintenance Shop	12.41	51.58	4.23	
Airfield Pavement Repair	12.25	0.00	1.73	32.00
Child Development Center	2.62	29.81	2.89	64.71
Hanger TF160	0.44	18.54	3.33	45.45
Outdoor Athletic Facility	6.10	13.33	3.29	54.55
Helicopter Hanger	2.96	22.41	2.61	57.69
Unit Chapel	3.65	40.00	4.07	66.67
Youth Activity Center	0.94	13.52	4.86	61.54
Applied Instruction Building	7.98	19.17	2.25	86.67
Water Storage Tank	1.69	-9.58	2.21	
Porter Road Bridge	12.79	27.22	7.29	27.27
Tank Driver Facility	5.85	25.94	6.62	40.63
Arts and Crafts Center	12.24	65.71	13.90	55.26
Youth Center	6.48	67.11	10.34	61.54
Child Support Center	4.59	-9.32	11.20	25.00
Child Support Center	5.41	11.69	7.65	28.57
Child Development Center	3.81	34.33	14.69	33.33
Hazardous Waste Facility	103.92	47.53	6.20	
Hazardous Landfill	21.00	26.45	2.92	68.49
Ammunition Workshop	8.90	46.30	9.14	
(AF) Composite Medical Facility	11.27	42.09	9.17	
Squadron Operations Facility	4.57	10.59	6.37	
Taxiway, Aprons, Lighting	-0.99	63.33	6.13	13.33
Aircraft Maintenance Dock	6.46	11.67	4.09	
Aircraft Fuel System Dock	4.00	19.39	10.12	50.00
Flight Simulator Facility	2.67	-9.44	19.48	35.00
Shortfield Assault Strip	25.50	21.48	5.17	45.45
Add/Alter Field Training Facility	24.72	103.33	14.66	74.19
Engine Inspection & Repair Facility	21.39	74.44	28.65	65.00
Vehicle Operations Facility	8.48	0.55	9.20	30.00
Gymnasium	3.65	18.52	8.18	
Alternate Taxiways	25.28	125.83	7.24	

Religious Education Facility	1.50	4.60	11.08	40.00
Child Development Center	4.39	3.25	6.71	34.48
Missile Inspection Facility	8.19	22.22	8.16	54.55
Enlisted Dormitory Alteration	2.44	2.78	6.11	
Test Facility	13.16	19.00	8.74	
Enlisted Dormitory Alteration 89	5.37	13.75	10.19	
Add/Alter Child Development Ctr.	5.18	40.00	27.64	30.43
Munitions Storage Complex	3.81	1.78	4.51	
Consolidated Support Center	8.34	25.93	7.05	40.00
Child Development Center	6.74	15.11	13.18	26.32
Dormitory	2.39	41.33	5.28	30.77
Child Development Center	6.70	63.94	13.17	32.56
Child Care Center	2.10	13.06	12.08	32.35
Add/Alter Wpns Support Facility	20.58	50.17	2.69	35.14
Aircraft Corrosion Control Facility	8.22	20.74	2.45	78.13
Depot Aircraft Hangar	4.71	2.08	2.34	44.83
C-141 Maintenance Hangars	5.02	15.06	1.01	47.62
Medical Training Facility, Phase 1	11.65	32.17	8.10	
Add to Wing Headquarters	2.08	16.04	10.97	
Weapons Systems Training Facility	6.15	29.78	15.25	16.67
Alter Technical Training Facility	7.51	-14.81	13.97	33.33
Wing Operations Facility	3.71	10.29	16.91	26.47
Add to Aircraft Systems Training	5.19	-2.20	5.17	5.00
Airmen Dining Hall	3.93	3.67	13.92	
Flight Simulator Facility	8.54	60.12	24.22	
Add/Alter Electric Substation	2.27	18.09	11.10	7.69
Child Development Center	11.00	26.94	30.53	42.03
Child Development Center	1.76	-1.79	18.54	26.67
Field Training Detachment	7.53	35.62	5.55	42.03
Radar Approach Control Facility	4.00	10.91	17.54	50.00
Upgrade Utilities	14.53	-7.17	6.69	68.48
Helicopter Hangar	13.57	10.00	14.08	28.85
Alter Maintenance Hangar	5.11	24.89	5.14	67.11
Maintenance Management Facility	3.28	-12.89	8.27	53.33
Visiting Officers' Quarters/ TLF	3.57	7.45	5.83	49.12
Control Tower	4.40	124.67	12.00	42.42
Security Lighting & Fencing	14.11	31.43	13.39	30.91
Fuel Cell/ Corrosion Control Floors	0.00	-3.33	4.30	20.00
Foreign Material Facility	2.43	1.28	4.98	70.83
Child Development Center	5.42	23.56	8.40	31.25
Special Intelligence Facility	17.03	2.86	5.93	54.76
(Navy) Aircraft Rapid Refuel Station	27.36	13.99	6.97	59.52
Aircraft Maintenance Hangar	2.87	0.00	1.87	38.46
Bachelor Enlisted Quarters	5.07	20.65	4.71	50.00
Naval Intelligence Center, Phase I	2.19	0.00	4.57	
Hazardous Waste Storage Facility	12.56	100.37	6.72	20.00
Category Average	8.48	27.76	8.30	41.84
Variance	141	1099	37	344

CATEGORIES AND PROJECTS	COST GROWTH (%)	SCHEDULE GROWTH (%)	MODIFICATIONS PER $ MILLION	MODIFICATIONS FROM DESIGN DEFICIENCIES (%)
POCOCK DESIGN-BUILD				
(Army) Golf Course	2.81	21.81	3.66	4.17
Guest House	5.52	-22.22	1.76	0
Enlisted Club	9.74	12.96	2.74	0
Youth Activity Center	-0.38	17.78	3.85	0
Auto Craft Center Addition	4.69	84.87	9.95	0
Golf Course Expansion	1.28	-44.44	3.16	10
NCO Club	1.89	21.64	2.6	0
NCO/Enlisted Club	1.08	43.87	5.13	0
CID Command Field Office Building	7.66	6.67	9.07	5
Golf Course and Clubhouse	8.26	24.66	2.96	12.5
Child Development Center	1.02	0	3.57	18.18
Child Development Center	6.39	134.52	13.86	49.33
Indoor Swimming Pool	0.98	17.38	6.59	6.67
Golf Course Clubhouse	10.54	44.05	5.3	0
Commissary	36.55	59.44	5.83	11.11
Commissary	3.93	16.48	1.41	0
(AF) Field Training Detachment Fac.	5.2	-5.58	3.53	7.14
Cryptologic Support Center	31.73	0.74		
Medical Clinic	3	5	2	33
DLI Dining Facility	1.45	81.25	7.51	9.09
DLI Student Enlisted Housing	3.85	81.25	4.69	8.51
DLI Student Officer Housing	4.15	12.35	2.8	
Replace Main Substation	-0.03	12	5.35	0
Child Development Center	7.8	37.87	31.8	12.5
Health Care Facility	11.68	15.77	5.42	35.96
Education Center	0.25	5.14	4.68	0
War Reserve Material Warehouse	4.13	10	7.13	0
Student Enlisted Dorms	3.04	7.65		
B-1 Avionics Facility	7.01	48.88	5.46	
Whole Blood Facility	5.29	15.6	4.06	
(Navy) Water Storage Tanks	2.62	8.7		
Family Services Center	4.64	-2.19	8.21	
Child Development Center	5.91	-12.53	18.16	
Child Development Center	-0.51	73.89	15.51	13.33
Child Development Center	0.19			
Centrifuge Trainer	11.72			
Bachelor Enlisted Quarters	2.57	7.41	1.51	16.67
Child Development Center	5.15	16.67	14.69	
Child Development Center	18.44	33.65	9.43	
Parking Structure	13.46	103.22	4.35	
Category Average	6.37	26.23	6.8	9.39
Variance	59	1285	36	157

CATEGORIES AND PROJECTS	COST GROWTH (%)	SCHEDULE GROWTH (%)	MODIFICATIONS PER $ MILLION	MODIFICATIONS FROM DESIGN DEFICIENCIES (%)
POCOCK COMBINATION				
(Army) Sparkman Center	4.3	18.46	1.26	4.11
Commissary Renovation	10.59	63.56	8.17	6.06
Special Purpose Facility	1.56	16.39	0.78	0
General Education Development Ctr.	6	5.96	3.72	0
Consolidated Support	5.34	17.23	3.36	1.59
(AF) Add/Alter Hydrant System	6.49	-15.28	4.92	28.95
Child Development Center	3.71	5.78	7.06	3.33
Underground Storage Tanks	18.22	20.56	7.28	36.36
Maintenance Docks & Hangars	7.43	7.3	3.18	0.58
Composite Medical Facility	20.33	-11.14	3.12	66.02
Add/Alter Library	41.2	32.78	7.08	20
Child Development Center	7.36	65.67	7.33	11.76
Upgrade Industrial Waste Treatment	1.15	11.54	1.24	0
Four Season Store	9.6	16.27	4.21	12.12
(Navy) Propulsion Training Facility	6.19	45.96	7.11	25.21
Shore Intermediate Maintenance Act.	17.51	-0.82	9.42	26.8
Category Average	10.44	18.76	4.95	15.18
Variance	100	541	7	329

APPENDIX B

STUDY DESIGN-BUILD PROJECT LIST

CATEGORIES AND PROJECTS	COST GROWTH (%)	SCHEDULE GROWTH (%)	MODIFICATIONS PER $ MILLION	MODIFICATIONS FROM DESIGN DEFICIENCIES (%)
STUDY DESIGN-BUILD				
CONSOLIDATED SU	3.91	17.23	1.67	0.00
CHILD DEV CTR	1.38	-0.76	3.56	18.18
SITE 5205 SI	1.66	0.00	3.63	25.00
UGRND STRG TANK	0.00	0.00	7.70	16.67
MUSK HI ENERGY	0.00	9.05	2.55	0.00
DEMO 14 BLDGS	-4.57	0.00	11.16	28.57
AUTO CRAFT SHOP	4.69	84.87	9.95	0.00
FIELD TNG FAC	5.20	-5.58	3.53	57.14
HAZ FAC CLOSURE	49.31	0.00	8.11	42.86
WINDOW AREA	7.13	-10.76	2.47	40.00
REMED LNDFILL 4	0.00	0.00	2.36	28.57
INERT STORAGE	3.75	2.00	10.84	22.22
ELEC SUBSTATION	5.02	-8.20	4.78	0.00
WRM WHSE	4.13	10.00	9.51	0.00
UNDERSTG TKS	2.08	-10.58	7.74	12.50
ICA. 3 SITES	0.44	0.00	1.47	33.33
CHILD DEV CNTR	7.24	65.67	7.74	11.11
ADD/ALT GLOBAL	7.75	27.33	12.22	11.43
UPG STOR TKS	25.35	-3.79	3.71	28.57
UPG INDUST WSTE	-0.15	47.35	2.76	72.73
BW GW MON	7.06	0.00	6.00	55.56
SITE 12. IRP	0.00	100.00	4.79	0.00
A-10 FACILITIES	1.70	29.91	6.36	19.73
COMMISSARY RENOVATION	14.12		7.67	6.25
ALT WTR SUPPLY	22.98		4.59	33.33
SWMU	0.00		3.33	25.00
HYDRANT FUEL SYSTEM	5.01		1.69	80.00
BOMBER LIVE ORD	6.77		2.29	22.22
MAIN DKS/HANGAR		7.30	3.29	16.76
Category Average	6.50	15.04	5.43	24.40
Variance	113	906	10	459

APPENDIX C

SURVEYS

FACILITY SATISFACTION SURVEY

(adopted from Pocock)

Instructions (To be filled out by someone familiar with this facility)

Please answer the following questions.

Your Name:______________________ **Your Title:**________________

Facility/Project: ________________ **Location:**________________

1. What is your satisfaction with the facility's planning/design?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

2. Given the design, what is your satisfaction with the constructed facility?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

3. How well does this facility meet your need?

1	2	3	4	5	6	7	8	9	10
very poorly				adequate					very well

4. If this facility did not meet your needs, was it because of inadequate design or construction?

5. Comments:

Thank you for your assistance!

DESIGN-BUILD PROJECT SATISFACTION SURVEY

Instructions (To be filled out by someone familiar with this facility)

Please answer the following questions.

Your Name:__________________________ **Your Title:**________________

Facility/Project: __________________ **Location:**__________________

1. Was this project the first design-build project for the district?

2. Was this project the first of its type (i.e. Child development center, hanger, hazardous waste disposal, etc.) to use design-build within the district?

3. Has the district worked with the design-build firm previously on other projects?

If yes, were the previous projects design-build?
design-bid-build?
other?

4. Was the owner (or a representative) involved in the development of the RFP?

5. Would you say that the needs of the owner were clearly defined for the RFP?

6. What percentage of the design would you estimate was included in the RFP?

10% 20% 30% 40% 50% Greater than 50%

7. How many claims were made against this project for design changes or omissions?

8. Did the design-build process require more, less or about the same amount of time to manage as the traditional design-bid-build approach?

(Please continue on reverse side)

DESIGN-BUILD PROJECT SATISFACTION SURVEY

(Continued)

9. What is your satisfaction with the facility's planning/design?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

10. Given the design, what is your satisfaction with the constructed facility?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

11. How satisfied are you with the design-build process with respect to this project?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

12. How satisfied are you with the design-build process in general?

1	2	3	4	5	6	7	8	9	10
very low				neutral					very high

13. Comments:

Thank you for your assistance.

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